

GRANT/TR/IN90

Final Technical Report

NASA Grant NAG2-986 Entitled:

"Integration of Planetary Protection Activities"

Submitted to:

***National Aeronautics and Space Administration
Ames Research Center***

By:

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Period of Performance: 5/1/1997 to 5/31/00

Background

Research and activities under this grant have focused on a systematic examination and analysis of critical questions likely to impact planetary protection (PP) controls and implementation for Mars sample return missions (MSR). Four areas in the non-scientific and social realms were selected for special attention because of their importance to future mission planning and concern about critical timing or possible economic impacts on MSR mission implementation. These include: 1) questions of legal uncertainty and the decision making process, 2) public perception of risks associated with sample return, 3) risk communication and Education/Public Outreach, and 4) planetary protection implications of alternative mission architectures—both robotic and human sample return missions. In its entirety, NAG 2-986 has encompassed 3 categories of activity: 1) research and analysis (Race), 2) subcontracted research (MacGregor/Decision Research) and 3) consulting services.

Progress and Accomplishments

The research conducted under this grant sought to answer questions about planetary protection for future Mars exploration missions by focusing on both forward and back contamination concerns. The research itself evolved over time in response to NASA's clarification of Mars exploration plans and particular mission architectures.

I. RESEARCH AND ANALYSIS:

During the overall grant period, Dr. Race has worked collaboratively on a number of major studies and projects:

MELTSWG (1997-98): As a member of the MELTSWG working group (Mars Exploration Long-Term Strategy Working Group), Dr Race contributed to a research study of Planetary Protection needs for a robotic sample return mission. Races' contributions emphasized environmental impact statement planning, NEPA compliance, public decision making, legal ambiguities and biocontainment needs associated with a planned 2005 sample return mission. The final report was presented and disseminated to NASA officials and engineers for use in planning the 2005 sample return mission.

1997 PROTOCOL WORKSHOP (1997-98): Race collaborated in planning and organizing a NASA workshop in 1997 on developing protocols for Mars sample return biocontainment. At the workshop, she chaired the subgroup on Biohazard Testing and subsequently co-authored the workshop report, which was published in 1999.

SSB SMALL BODIES TASK GROUP (1997-98): Race was appointed to the National Research Council's Space Studies Board Task Group on Sample Return from Small Solar System Bodies. The task group's work continued into 1998, and resulted in publication of a major advisory report (1998) on biocontainment needs for samples returned from solar system bodies other than Mars.

MSHARP (Mars Sample Handling Requirements Panel) (1997-99): Race was appointed to MSHARP in 1997, a panel designated by NASA headquarters to define requirements for collection, transport, handling, testing, and curation of samples from Mars. The two year study culminated in a final report in 1999.

MSHP Workshop Series (Mars Sample Handling Protocol) (1999-2000): Since 1999, Race has been a member of the Organizing Committee for planning and implementing an international series of workshops to develop protocols for life detection, biohazard assessment and other handling issues (sterilization, curation, facilities implications etc) for samples returned from Mars. Work is expected to continue throughout 2000.

MRSH (Mars Return Sample Handling): (2000) Race is currently a participant in a JPL/ARC/JSC joint working group studying implementation issues of planned Mars sample return activities and associated facilities. In addition to providing information on biocontainment and biohazard assessment, Race is chairing a subgroup charged with recommending minimum requirements for a potential Mars Receiving Facility. These requirements would be used as draft site selection criteria for evaluating potential locations in the 'siting decision' process required by NEPA.

Risk Communication and Outreach (1999-2000): Dr. Race has continued working with colleagues at JPL in reviewing risk communication plans for Mars Sample Return. This has involved the integration of information about risk perceptions, NEPA process decision making, planetary protection concerns, legal and regulatory requirements, the mass media, and NASA E/PO strategies.

She has also increased attention on education and outreach for MSR and Astrobiology. In particular, she initiated contact with the Chabot Observatory and Science Center in Oakland, CA and helped integrate elements of Mars Exploration and Astrobiology into their Summer Educators workshop. Dr. Race partnered with Chabot and obtained funding through NASA's IDEAs Grant Program to develop Teacher Resource Kits for regional middle schools. She also initiated contact with educational researchers at University of California at Berkeley, School of Education. Discussions currently underway to develop computer based science modules on Astrobiology and Mars exploration that are linked with national and state science education standards.

II. CONTINUED RESEARCH ON RISK PERCEPTIONS:

During the grant period, Dr. Race continued collaborative research work with Donald MacGregor and Decision Research Inc., focusing on three general categories of activities: a) analysis of public and expert risk perceptions of Mars sample return via focus group studies and survey research, b) dissemination of research findings both inside and outside NASA via presentations and publications, and c) monitoring and research on trends in citizens' involvement and use of the Internet. Research results have provided helpful information in developing communication plans for future Mars sample return missions, and in anticipating potential legal and social impediments that may occur at various phases of the mission. During the last year of the grant, the project undertook two white paper reports that dealt with (a) the

role of the Internet in environmental decision making, and (b) an examination of the psychological and social factors accounting for public and activist response to the Cassini space mission. Both papers address issues relevant to planetary protection, public perception of sample return risks, and the use of nuclear materials on space missions.

III. SUPPORT OF PLANETARY PROTECTION PROGRAM VIA CONSULTING ACTIVITIES:

During the period of performance, the grant has also provided support to NASA's Planetary Protection Program through an agreement with the Marine Biological Laboratory for communications, logistics, and presentation support. In addition, in-kind assistance was provided to the Solar System Exploration program in supporting its efforts in developing biological training opportunities at MBL. In particular, the grant supported Dr. George Reynolds of Princeton University, Dr. Cindy Van Dover of the College of William and Mary, and Dr. Christopher Chyba during their respective research at MBL and Woods Hole Oceanographic Institution. Dr. Reynolds investigated the potential mechanisms and consequences of light sources that may occur at hydrothermal vents. Dr. Reynolds also consulted with others in the study of hydrothermal vents, including Dr. Van Dover, Dr. Alan Chave of WHOI, and Dr. John Rummel, the NASA Planetary Protection Officer. This collaborative research is helpful in assessing the potential for life on Europa and in expanding scientific understanding of the potential origin of photosynthesis on Earth, and possibly on Mars. Dr. Chyba served as a zero-cost Co-investigator during the summer 1999 and provided expertise and liaison with the scientific community. He also provided consultation in support of planetary protection issues and concerns within the framework of outer planet missions. Finally, the grant also supported Dr. Lorraine Olenzenski of the University of Connecticut to develop and teach a hands-on microbial biology short course for Project Managers and Engineers at JPL in 1999.

III. PAPERS, ABSTRACTS AND PUBLISHED WORKS by Principal Investigator

MacGregor, D.G., and M.S. Race. 2000. Social amplification and attenuation of space mission risks: The case of Cassini. Decision Research Report #00-3. Eugene, OR: Decision Science Research Institute.

MacGregor, D.G., and M.S. Race, 2000. Computer-mediated public involvement in environmental decision making: Implications for NASA planetary protection programs. Decision Research Report #00-4. Eugene, OR: Decision Science Research Institute.

Race, M.S. and R.O. Randolph, 1999. Ethical Considerations in Astrobiology: A Proposal for Guidelines Applicable to the Discovery of Non-Intelligent Extraterrestrial Life, Poster: NASA Astrobiology Science Conference, Nov. '99; Ames Research Center; Paper: in preparation.

Race, M.S. and D.G. MacGregor, 1999. Integrating Public Perspectives in Sample Return Planning. Adv. In Space Research, v. 25(2)

Orgel, L., M. A'Hearn, J. Bada, J. Baross, C. Chapman, M. Drake, J. Kerridge, M. Race, M. Sogin, and S. Squyres, 2000. Sample Return from Small Bodies, *Adv. In Space Res.* v. 25(2), pp. 239-248.

Race, M.S., J. Allton, C. Allen, and J. Richmond, 1999. Planning Considerations for Mars Sample Return Containment. *J. American Biological Safety Assn. (JABSA)* vol. 4(2) pp.53-59.

DeVincenzi, D., J. Bagby, M. Race, and J. Rummel (eds.), 1999. *Proceedings: Mars Sample Quarantine Protocol Workshop*, NASA/CP-1999-208772, April 1999. NASA Ames Res. Ctr., Moffett Field, CA

Race, M.S., J.H. Allton, C.C. Allen, and J.Y. Richmond, 1999. Containment Design Concepts for Extraterrestrial Sample Materials, in: "An Anthology of Biosafety: I. Perspectives on Laboratory Design," J.Y. Richmond (ed.), American Biological Safety Association (ABSA), Mundelein, IL

MSHARP, 1999, (Carr, M.H., J. Bada, S. Bogard, B. Clark, M. Drake, D. DeVincenzi, D. McCleese, K. Nealson, J. Papike, M. Race, and S. Stahl), Mars Sample Handling and Requirements Panel, Final Report, NASA/TM-1999-209145, Jet Propulsion Laboratory (JPL), Pasadena, CA

Race, M.S. and J.D. Rummel. 1999, Bring 'em back alive—or at least carefully. *Ad Astra* 11:37-40.

De Vincenzi, D.L., Race, M.S., and H.P. Klein, 1998. Planetary Protection, Sample Return Missions and Mars Exploration: History, Status and Future Needs. *J. Geophysical Research* 103(E12) 28,577-28,585.

MacGregor, D.G., P. Slovic, and M.S. Race, 1998. Lay and Expert Perceptions of Planetary Protection, Report No 98-2, Decision Research, Eugene OR.

MacGregor, Donald G., and Margaret S. Race, 1998. Microbiologists' Perceptions of Planetary Protection, Report No. 98-3, Decision Research, Eugene OR.

National Research Council, 1998. (Orgel, L, M. A'Hearn, J. Bada, J. Baross, C. Chapman, M. Drake, J. Kerridge, M. Race, M. Sogin, and S. Squyres) *Evaluating the Biological Potential in Samples Returned from Planetary Satellites and Small Solar System Bodies: Framework for Decision Making.*, National Academy Press, Washington, D.C.

Race, M.S., 1998. Mars Sample Return and Planetary Protection in a Public Context. *Advances In Space Research* 22(3), 391-99.

Race, M.S., 1998. Mars Sample Return and Biocontainment., *J. Amer. Biological Safety Assn.*, 3(1), pages 22-24.

Randolph, R., M.S. Race, and C. McKay, 1997. Reconsidering the Ethical and Theological Implications of Extraterrestrial Life., CTNS Bulletin v. 17(3), 1-8, CTNS, Berkeley, CA.

V. OTHER PAPERS AND PUBLICATIONS UNDER THIS GRANT:

Rummel, J.D., 1999. Implementing planetary protection requirements for sample return missions., Adv. In Space Res. 2000

Rummel, J.D. and C.L. Van Dover, 1999. Shedding Some Life on the Possibility of European Life. 12th International Conference on the Origins of Life (ISSOL), La Jolla, California.

Meech, K. and J.D. Rummel, 1999. A new era in the search for life in the universe. Bioastronomy News 11(3):1-2.

Rummel, J.D., 1998. Scientific issues regarding the release of extraterrestrial materials collected by spaceflight missions, Adv. In Space Res. 22(3),: 383-89

White, S.N. Chave, A.D., Bailey, J.W., Van Dover, C.L., Reynolds, G.T., Gaidos, E. and J.A. Tyson, 1998. Images of Ambient Light at High-Temperature Black Smokers and Flange pools, Endeavor Segment, Juan de Fuca Ridge. Poster presented at AGU Fall Meeting.

Rummel, JD 1997. Book Review of "the Biological Universe: The 20th Century Extraterrestrial Life Debate and the Limits of Science", by Steven J. Dick; Icarus 127: June '97)

Van Dover, C.L. 1999. Life and light at deep-sea hydrothermal vents. Bioastronomy '99 Meeting, Kona, HI. (Oral Presentation)

White, S.N., A.D. Chave, G.T. Reynolds, E. Gaidos, J.A. Tyson and C.L. Van Dover. 2000. Variations in ambient light emissions from black smokers and flange pools on the Juan de Fuca Ridge. Geophys. Res. Lett. 27:1151-1154.

Reynolds, G.T., A.D. Chave, and R.A. Lutz. Sources of Light in the Deep Ocean. 2000. Reviews of Geophysics (in press)

VI. WORKSHOPS, SEMINARS AND PRESENTATIONS by Principal Investigator

During the period of performance (5/1/97 to 6/1/00) numerous presentations were made to NASA and the space community, to university and scientific audiences, and to the general public, including the following:

Workshops and Special Seminars: Dr. Race conducted workshops and special public presentations on issues in Mars Sample Return, Planetary Protection, Astrobiology, and Public Risk Communications at numerous conferences and meetings including:

American Association for the Advancement of Science (AAAS) 1998; American Society of Microbiology, (1998); Center for Theology and Natural Sciences (CTNS) (1997, '98, '99); American Biological Safety Association (ABSA), 1997, '98), COSPAR (1998); International Space University (1998); University of Georgia (1998), Concordia College Faith, Science and the Future Conference (1998), and George Washington University Astrobiology Conference (1998).

In addition, she delivered lectures and seminars to numerous professional, university, and public audiences including: University of Hawaii (1998); University of California at Berkeley (1997, '99, '99); San Francisco State University (1997, '98), Stanford University (1998, '99); JPL (1998, '99); NASA Planetary Protection Task Force (1999); NASA Sample Handling Protocol Workshop (1997, 2000); SSB COMPLEX special meetings on Asteroid Risks (1998) and Life Detection (1999); NASA Ames Astrobiology Academy (1997, 1998); NASA Ames—Space Camp (1998); NASA—Lunar and Planetary Institute Educators Workshop (1998); Societal Implications of Astrobiology (1999); Ball State University (1999); The Tech Museum, San Jose CA. (1999); Foothill College/Silicon Valley Astronomy Lectures (2000); Hoosier Association of Science Teachers (2000); NASA Environmental Managers Conference (2000); and NASA-Ames Foothill DeAnza Internship Program (2000).

Race was also a participant at many NASA working groups including: NASA Ames Astrobiology Roadmap Workshop (1998); and various JPL/NASA Workshops on Vostok-Europa (1997); Cleaning and Sterilization Technologies (1999); Europa/Titan (1999); and Deep Drilling (1998).